Assignment 8 by Ben Geiser

First, I need to load in the necessary libraries and the data.

Now I create the actual models that I will be able to analyze in the homework questions.

```
#create the data that will be used for the loop
m2_ld_rgdp = window(ld_rgdp, end = "2011-12-31")
m2_spread = window(spread, end = "2011-12-31")
T2 = dim(m2_ld_rgdp)[1]

#equation 1 loop
for (h in c(1,4,8)){
    csum_ld_rgdp = 0*m2_ld_rgdp
  for (i in (1:(T2-h))){
    csum_ld_rgdp[i,] =sum(m2_ld_rgdp[(i+1):(i+h),])
  }
  cat("Current forecasting horizon: ", h)
  print(cbind(head(m2_ld_rgdp,10),head(csum_ld_rgdp,10)))
  reg = lm(csum_ld_rgdp[1:(T2-h),]/h~m2_spread[1:(T2-h),])
  print(summary(reg))
  print(coeftest(reg,vcov. = NeweyWest(reg, lag = round(0.75*T2^(1/3)))))
  cat("MSFE for: ", h)
  print(mean(csum_ld_rgdp[1:(T2-h),]/h-predict(reg)^2))
}
```

```
## Current forecasting horizon:  1              rgdp      rgdp.1
## 1976 Q3 0.547205858 0.722236560
## 1976 Q4 0.722236560 1.174558573
## 1977 Q1 1.174558573 1.925456614
## 1977 Q2 1.925456614 1.788270600
## 1977 Q3 1.788270600 0.002185748
## 1977 Q4 0.002185748 0.318654997
## 1978 Q1 0.318654997 3.791476643
## 1978 Q2 3.791476643 1.000495438
## 1978 Q3 1.000495438 1.335189603
## 1978 Q4 1.335189603 0.179625864
##
## Call:
## lm(formula = csum_ld_rgdp[1:(T2 - h), ]/h ~ m2_spread[1:(T2 -
##     h), ])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.96183 -0.35657  0.06224  0.36557  3.11179
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)              0.65562    0.08999   7.286 2.18e-11 ***
## m2_spread[1:(T2 - h), ]  0.05348    0.07068   0.757    0.451
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7903 on 139 degrees of freedom
## Multiple R-squared:  0.004101,   Adjusted R-squared:  -0.003063
## F-statistic: 0.5724 on 1 and 139 DF,  p-value: 0.4506
##
##
## t test of coefficients:
##
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)              0.655619   0.128330  5.1089 1.05e-06 ***
## m2_spread[1:(T2 - h), ] 0.053477   0.094299  0.5671   0.5716
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## MSFE for:  1[1] 0.2068853
## Current forecasting horizon:  4               rgdp   rgdp.1
## 1976 Q3 0.547205858 5.610522
## 1976 Q4 0.722236560 4.890472
## 1977 Q1 1.174558573 4.034568
## 1977 Q2 1.925456614 5.900588
## 1977 Q3 1.788270600 5.112813
## 1977 Q4 0.002185748 6.445817
## 1978 Q1 0.318654997 6.306788
## 1978 Q2 3.791476643 2.622174
## 1978 Q3 1.000495438 2.361804
## 1978 Q4 1.335189603 1.276377
##
## Call:
## lm(formula = csum_ld_rgdp[1:(T2 - h), ]/h ~ m2_spread[1:(T2 -
##     h), ])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.76616 -0.24997  0.02159  0.32737  1.36643
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)               0.62263    0.06093  10.219   <2e-16 ***
## m2_spread[1:(T2 - h), ]  0.09128    0.04926   1.853    0.066 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5337 on 136 degrees of freedom
## Multiple R-squared:  0.02463,    Adjusted R-squared:  0.01746
## F-statistic: 3.435 on 1 and 136 DF,  p-value: 0.06601
##
##
## t test of coefficients:
##
##                          Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)             0.622633   0.209651  2.9699 0.003523 **
## m2_spread[1:(T2 - h), ] 0.091284   0.112151  0.8139 0.417105
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## MSFE for:  4[1] 0.2037552
## Current forecasting horizon:  8               rgdp     rgdp.1
## 1976 Q3 0.547205858 10.7233352
## 1976 Q4 0.722236560 11.3362882
## 1977 Q1 1.174558573 10.3413555
## 1977 Q2 1.925456614  8.5227616
## 1977 Q3 1.788270600  7.4746168
## 1977 Q4 0.002185748  7.7221939
## 1978 Q1 0.318654997  7.7175644
## 1978 Q2 3.791476643  1.8440917
## 1978 Q3 1.000495438  0.7246784
## 1978 Q4 1.335189603  1.2372379
##
## Call:
## lm(formula = csum_ld_rgdp[1:(T2 - h), ]/h ~ m2_spread[1:(T2 -
##     h), ])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.04088 -0.25121 -0.02301  0.28931  0.92021
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)              0.58717    0.04623  12.701  < 2e-16 ***
## m2_spread[1:(T2 - h), ]  0.13782    0.03924   3.512  0.00061 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4033 on 132 degrees of freedom
## Multiple R-squared:  0.08545,    Adjusted R-squared:  0.07852
## F-statistic: 12.33 on 1 and 132 DF,  p-value: 0.0006097
##
##
## t test of coefficients:
##
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)             0.587173   0.195238  3.0075 0.003155 **
## m2_spread[1:(T2 - h), ] 0.137818   0.064841  2.1255 0.035409 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## MSFE for:  8[1] 0.1974337
```

```r
#create a loop to compute equation 2
for (h in c(1,4,8)){
  reg = lm(m2_ld_rgdp[(1+h):T2,]~m2_spread[1:(T2-h)])
  cat("Current forecasting horizon: ", h)
  print(summary(reg))
  print(cbind(head(m2_ld_rgdp[(1+h):T2,],10),head(m2_spread[1:(T2-h),],10)))
```

```
  cat("MSFE for: ", h)
  print(mean(m2_ld_rgdp[(1+h):T2,]-predict(reg)^2))
}
```

```
## Current forecasting horizon:  1
## Call:
## lm(formula = m2_ld_rgdp[(1 + h):T2, ] ~ m2_spread[1:(T2 - h)])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.96183 -0.35657  0.06224  0.36557  3.11179
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            0.65562    0.08999   7.286 2.18e-11 ***
## m2_spread[1:(T2 - h)]  0.05348    0.07068   0.757    0.451
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7903 on 139 degrees of freedom
## Multiple R-squared:  0.004101,   Adjusted R-squared:  -0.003063
## F-statistic: 0.5724 on 1 and 139 DF,  p-value: 0.4506
##
##                rgdp spread
## 1976 Q3          NA   1.22
## 1976 Q4 0.722236560   1.47
## 1977 Q1 1.174558573   1.41
## 1977 Q2 1.925456614   1.12
## 1977 Q3 1.788270600   0.59
## 1977 Q4 0.002185748   0.56
## 1978 Q1 0.318654997   0.45
## 1978 Q2 3.791476643   0.14
## 1978 Q3 1.000495438  -0.14
## 1978 Q4 1.335189603  -0.83
## 1979 Q1 0.179625864     NA
## MSFE for:  1[1] 0.2068853
## Current forecasting horizon:  4
## Call:
## lm(formula = m2_ld_rgdp[(1 + h):T2, ] ~ m2_spread[1:(T2 - h)])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.90570 -0.34657  0.06278  0.35398  3.08566
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            0.64211    0.09028   7.112 5.89e-11 ***
## m2_spread[1:(T2 - h)]  0.05688    0.07298   0.779    0.437
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7908 on 136 degrees of freedom
## Multiple R-squared:  0.004446,   Adjusted R-squared:  -0.002874
```

```
## F-statistic: 0.6074 on 1 and 136 DF,  p-value: 0.4371
##
##                rgdp spread
## 1976 Q3          NA   1.22
## 1976 Q4          NA   1.47
## 1977 Q1          NA   1.41
## 1977 Q2          NA   1.12
## 1977 Q3 1.788270600   0.59
## 1977 Q4 0.002185748   0.56
## 1978 Q1 0.318654997   0.45
## 1978 Q2 3.791476643   0.14
## 1978 Q3 1.000495438  -0.14
## 1978 Q4 1.335189603  -0.83
## 1979 Q1 0.179625864     NA
## 1979 Q2 0.106862713     NA
## 1979 Q3 0.740125767     NA
## 1979 Q4 0.249762867     NA
## MSFE for:  4[1] 0.2115289
## Current forecasting horizon:  8
## Call:
## lm(formula = m2_ld_rgdp[(1 + h):T2, ] ~ m2_spread[1:(T2 - h)])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.74365 -0.33596  0.04478  0.34145  1.81451
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            0.55243    0.08447   6.540 1.23e-09 ***
## m2_spread[1:(T2 - h)]  0.14604    0.07170   2.037   0.0437 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7368 on 132 degrees of freedom
## Multiple R-squared:  0.03047,    Adjusted R-squared:  0.02313
## F-statistic: 4.149 on 1 and 132 DF,  p-value: 0.04366
##
##               rgdp spread
## 1976 Q3         NA   1.22
## 1976 Q4         NA   1.47
## 1977 Q1         NA   1.41
## 1977 Q2         NA   1.12
## 1977 Q3         NA   0.59
## 1977 Q4         NA   0.56
## 1978 Q1         NA   0.45
## 1978 Q2         NA   0.14
## 1978 Q3  1.0004954  -0.14
## 1978 Q4  1.3351896  -0.83
## 1979 Q1  0.1796259     NA
## 1979 Q2  0.1068627     NA
## 1979 Q3  0.7401258     NA
## 1979 Q4  0.2497629     NA
## 1980 Q1  0.3140255     NA
## 1980 Q2 -2.0819961     NA
```

```
## 1980 Q3 -0.1189178     NA
## 1980 Q4  1.8477491     NA
## MSFE for:  8[1] 0.2057923
```

Now that the coding has been done, we can answer the homework questions.

1.) These models perform significantly better than the models in the previous homework. This can be seen because the MSFE for the subsample in the previous homework was 3.98, whereas the MSFE for the regressions in this homework are much lower, meaning that the predicted values are much closer than the observed values.

2.) The MSFEs for the models in equations 1 and 2 and all the forecasting horizons are as follows: Equation 1: h=1:0.2068853 h=4:0.2037552 h=8:0.1974337

Equation 2: h=1:0.2068853 h=4:0.2115289 h=8:0.2057923

As can be seen above, equation 1 where the forecasting horizon = 8 is the best model because the MSFE is the lowest, meaning the predicted values are the closest to the actual values in this model.

3.) In order to see if COVID impacts the models, I will have to include COVID in the time frame and then rerun the models to see if the rankings change.

```
#create the data that will be used for the loop
m2_ld_rgdp = window(ld_rgdp, end = "2022-04-13")
m2_spread = window(spread, end = "2022-04-13")
T2 = dim(m2_ld_rgdp)[1]

#equation 1 loop
for (h in c(1,4,8)){
    csum_ld_rgdp = 0*m2_ld_rgdp
  for (i in (1:(T2-h))){
    csum_ld_rgdp[i,] =sum(m2_ld_rgdp[(i+1):(i+h),])
  }
  cat("Current forecasting horizon: ", h)
  print(cbind(head(m2_ld_rgdp,10),head(csum_ld_rgdp,10)))
  reg = lm(csum_ld_rgdp[1:(T2-h),]/h~m2_spread[1:(T2-h),])
  print(summary(reg))
  print(coeftest(reg,vcov. = NeweyWest(reg, lag = round(0.75*T2^(1/3)))))
  cat("MSFE for: ", h)
  print(mean(csum_ld_rgdp[1:(T2-h),]/h-predict(reg)^2))
}
```

```
## Current forecasting horizon:  1               rgdp      rgdp.1
## 1976 Q3 0.547205858 0.722236560
## 1976 Q4 0.722236560 1.174558573
## 1977 Q1 1.174558573 1.925456614
## 1977 Q2 1.925456614 1.788270600
## 1977 Q3 1.788270600 0.002185748
## 1977 Q4 0.002185748 0.318654997
## 1978 Q1 0.318654997 3.791476643
## 1978 Q2 3.791476643 1.000495438
## 1978 Q3 1.000495438 1.335189603
## 1978 Q4 1.335189603 0.179625864
##
## Call:
## lm(formula = csum_ld_rgdp[1:(T2 - h), ]/h ~ m2_spread[1:(T2 -
```

```
##     h), ])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.9985 -0.3095  0.0479  0.3879  6.6381
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)               0.60909    0.12376   4.921 1.94e-06 ***
## m2_spread[1:(T2 - h), ]  0.05813    0.09624   0.604    0.547
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.162 on 179 degrees of freedom
## Multiple R-squared:  0.002034,   Adjusted R-squared:  -0.003541
## F-statistic: 0.3649 on 1 and 179 DF,  p-value: 0.5466
##
##
## t test of coefficients:
##
##                          Estimate Std. Error t value  Pr(>|t|)
## (Intercept)              0.609088   0.123110  4.9475 1.725e-06 ***
## m2_spread[1:(T2 - h), ] 0.058131   0.082560  0.7041    0.4823
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## MSFE for:  1[1] 0.2208257
## Current forecasting horizon:  4               rgdp   rgdp.1
## 1976 Q3 0.547205858 5.610522
## 1976 Q4 0.722236560 4.890472
## 1977 Q1 1.174558573 4.034568
## 1977 Q2 1.925456614 5.900588
## 1977 Q3 1.788270600 5.112813
## 1977 Q4 0.002185748 6.445817
## 1978 Q1 0.318654997 6.306788
## 1978 Q2 3.791476643 2.622174
## 1978 Q3 1.000495438 2.361804
## 1978 Q4 1.335189603 1.276377
##
## Call:
## lm(formula = csum_ld_rgdp[1:(T2 - h), ]/h ~ m2_spread[1:(T2 -
##     h), ])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.97814 -0.23690  0.03606  0.32791  2.26514
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)               0.57610    0.06164   9.347   <2e-16 ***
## m2_spread[1:(T2 - h), ]  0.08506    0.04797   1.773   0.0779 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 0.5778 on 176 degrees of freedom
## Multiple R-squared:  0.01755,    Adjusted R-squared:  0.01197
## F-statistic: 3.144 on 1 and 176 DF,  p-value: 0.07791
##
##
## t test of coefficients:
##
##                          Estimate Std. Error t value  Pr(>|t|)
## (Intercept)              0.576097   0.153112  3.7626 0.0002288 ***
## m2_spread[1:(T2 - h), ] 0.085061   0.087766  0.9692 0.3337843
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## MSFE for:  4[1] 0.2204271
## Current forecasting horizon:  8               rgdp     rgdp.1
## 1976 Q3 0.547205858 10.7233352
## 1976 Q4 0.722236560 11.3362882
## 1977 Q1 1.174558573 10.3413555
## 1977 Q2 1.925456614  8.5227616
## 1977 Q3 1.788270600  7.4746168
## 1977 Q4 0.002185748  7.7221939
## 1978 Q1 0.318654997  7.7175644
## 1978 Q2 3.791476643  1.8440917
## 1978 Q3 1.000495438  0.7246784
## 1978 Q4 1.335189603  1.2372379
##
## Call:
## lm(formula = csum_ld_rgdp[1:(T2 - h), ]/h ~ m2_spread[1:(T2 -
##     h), ])
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.51137 -0.25020  0.01847  0.23481  0.99443
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)               0.55093    0.04282  12.865  < 2e-16 ***
## m2_spread[1:(T2 - h), ]  0.09467    0.03303   2.866  0.00467 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3972 on 172 degrees of freedom
## Multiple R-squared:  0.04559,    Adjusted R-squared:  0.04004
## F-statistic: 8.215 on 1 and 172 DF,  p-value: 0.004673
##
##
## t test of coefficients:
##
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)              0.550925   0.172062  3.2019 0.001627 **
## m2_spread[1:(T2 - h), ] 0.094670   0.067322  1.4062 0.161463
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## MSFE for:  8[1] 0.223453
```

```r
#create a loop to compute equation 2
for (h in c(1,4,8)){
  reg = lm(m2_ld_rgdp[(1+h):T2,]~m2_spread[1:(T2-h)])
  cat("Current forecasting horizon: ", h)
  print(summary(reg))
  print(cbind(head(m2_ld_rgdp[(1+h):T2,],10),head(m2_spread[1:(T2-h),],10)))
  cat("MSFE for: ", h)
  print(mean(m2_ld_rgdp[(1+h):T2,]-predict(reg)^2))
}
```

```
## Current forecasting horizon:  1
## Call:
## lm(formula = m2_ld_rgdp[(1 + h):T2, ] ~ m2_spread[1:(T2 - h)])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.9985 -0.3095  0.0479  0.3879  6.6381
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            0.60909    0.12376   4.921 1.94e-06 ***
## m2_spread[1:(T2 - h)]  0.05813    0.09624   0.604    0.547
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.162 on 179 degrees of freedom
## Multiple R-squared:  0.002034,   Adjusted R-squared:  -0.003541
## F-statistic: 0.3649 on 1 and 179 DF,  p-value: 0.5466
##
##                rgdp spread
## 1976 Q3          NA   1.22
## 1976 Q4 0.722236560   1.47
## 1977 Q1 1.174558573   1.41
## 1977 Q2 1.925456614   1.12
## 1977 Q3 1.788270600   0.59
## 1977 Q4 0.002185748   0.56
## 1978 Q1 0.318654997   0.45
## 1978 Q2 3.791476643   0.14
## 1978 Q3 1.000495438  -0.14
## 1978 Q4 1.335189603  -0.83
## 1979 Q1 0.179625864     NA
## MSFE for:  1[1] 0.2208257
## Current forecasting horizon:  4
## Call:
## lm(formula = m2_ld_rgdp[(1 + h):T2, ] ~ m2_spread[1:(T2 - h)])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.9840 -0.3156  0.0597  0.3770  6.6636
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)            0.61038    0.12453   4.901 2.15e-06 ***
## m2_spread[1:(T2 - h)]  0.04590    0.09692   0.474    0.636
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.167 on 176 degrees of freedom
## Multiple R-squared:  0.001273,   Adjusted R-squared:  -0.004402
## F-statistic: 0.2243 on 1 and 176 DF,  p-value: 0.6364
##
##                rgdp spread
## 1976 Q3          NA   1.22
## 1976 Q4          NA   1.47
## 1977 Q1          NA   1.41
## 1977 Q2          NA   1.12
## 1977 Q3 1.788270600   0.59
## 1977 Q4 0.002185748   0.56
## 1978 Q1 0.318654997   0.45
## 1978 Q2 3.791476643   0.14
## 1978 Q3 1.000495438  -0.14
## 1978 Q4 1.335189603  -0.83
## 1979 Q1 0.179625864     NA
## 1979 Q2 0.106862713     NA
## 1979 Q3 0.740125767     NA
## 1979 Q4 0.249762867     NA
## MSFE for:  4[1] 0.2250751
## Current forecasting horizon:  8
## Call:
## lm(formula = m2_ld_rgdp[(1 + h):T2, ] ~ m2_spread[1:(T2 - h)])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.9516 -0.2788  0.0497  0.3728  6.6934
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            0.56502    0.12404   4.555 9.89e-06 ***
## m2_spread[1:(T2 - h)]  0.07420    0.09568   0.775    0.439
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.15 on 172 degrees of freedom
## Multiple R-squared:  0.003484,   Adjusted R-squared:  -0.002309
## F-statistic: 0.6014 on 1 and 172 DF,  p-value: 0.4391
##
##               rgdp spread
## 1976 Q3         NA   1.22
## 1976 Q4         NA   1.47
## 1977 Q1         NA   1.41
## 1977 Q2         NA   1.12
## 1977 Q3         NA   0.59
## 1977 Q4         NA   0.56
## 1978 Q1         NA   0.45
## 1978 Q2         NA   0.14
## 1978 Q3  1.0004954  -0.14
```

```
## 1978 Q4  1.3351896  -0.83
## 1979 Q1  0.1796259     NA
## 1979 Q2  0.1068627     NA
## 1979 Q3  0.7401258     NA
## 1979 Q4  0.2497629     NA
## 1980 Q1  0.3140255     NA
## 1980 Q2 -2.0819961     NA
## 1980 Q3 -0.1189178     NA
## 1980 Q4  1.8477491     NA
## MSFE for:  8[1] 0.227623
```

Now I can view the MSFE for the models. Equation 1: h=1:0.2208257 h=4:0.2204271 h=8:0.223453

Equation 2: h=1:0.2208257 h=4:0.2250751 h=8:0.227623

So here with the inclusion of COVID, we can see that the MSFE for each model has changed a bit, but has it changed significantly for any? It can easily be seen that COVID, while changing the MSFE for each slightly, does not have a statistical impact on the MSFE.

4.) the model constructed below will predict the next 3 quarters of 2022. Because the best model was equation 1, I used equation 1 and simply adapted the time frame and the periods (h).

```
m2_ld_rgdp = window(ld_rgdp, start = "2011-12-31", end = "2022-04-13")
m2_spread = window(spread, start = "2011-12-31", end = "2022-04-13")
T2 = dim(m2_ld_rgdp)[1]



for (h in c(3)){
    csum_ld_rgdp = 0*m2_ld_rgdp
  for (i in (1:(T2-h))){
    csum_ld_rgdp[i,] =sum(m2_ld_rgdp[(i+1):(i+h),])
  }
  cat("Current forecasting horizon: ", h)
  print(cbind(head(m2_ld_rgdp,10),head(csum_ld_rgdp,10)))
  reg = lm(csum_ld_rgdp[1:(T2-h),]/h~m2_spread[1:(T2-h),])
  print(summary(reg))
  print(coeftest(reg,vcov. = NeweyWest(reg, lag = round(0.75*T2^(1/3)))))
  cat("MSFE for: ", h)
  print(mean(csum_ld_rgdp[1:(T2-h),]/h-predict(reg)^2))

}
```

```
## Current forecasting horizon:  3              rgdp    rgdp.1
## 2012 Q1  0.8145960 0.7393321
## 2012 Q2  0.4548241 1.1485539
## 2012 Q3  0.1747302 1.1131119
## 2012 Q4  0.1097778 1.7918703
## 2013 Q1  0.8640459 1.6364786
## 2013 Q2  0.1392882 1.1464663
## 2013 Q3  0.7885363 1.6338839
## 2013 Q4  0.7086541 2.0834580
## 2014 Q1 -0.3507241 2.8821705
## 2014 Q2  1.2759539 2.4162407
##
```

```
## Call:
## lm(formula = csum_ld_rgdp[1:(T2 - h), ]/h ~ m2_spread[1:(T2 -
##     h), ])
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.6251 -0.2166 -0.0070  0.2643  2.9636
##
## Coefficients:
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)                0.2102     0.2838   0.740    0.464
## m2_spread[1:(T2 - h), ]    0.2576     0.2139   1.204    0.237
##
## Residual standard error: 0.9022 on 35 degrees of freedom
## Multiple R-squared:  0.0398, Adjusted R-squared:  0.01236
## F-statistic: 1.451 on 1 and 35 DF,  p-value: 0.2365
##
##
## t test of coefficients:
##
##                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)               0.21016    0.55644  0.3777   0.7079
## m2_spread[1:(T2 - h), ]  0.25762    0.32702  0.7878   0.4361
##
## MSFE for:  3[1] 0.2180832
```

According to my model, GDP growth should increase by .25762 percent in the next three quarters. I can also construct predictive intervals in order to see how certain my prediction is.